

quality. Cranberries made excellent progress and at the end of the month were nearing maturity; the yield promises to be large and the quality excellent.—*W. M. Wilson.*

Wyoming.—On the whole the month was unfavorable for growing crops and range lands. It was abnormally dry and practically amounted to a drought. Weather was very favorable for haying, but so damaging to

ranges that no grass was left at end of month. Prospect for winter feed is bad in sections. Alfalfa and native hay crop all in, with average yield for State as a whole. Grain ripened slowly on account of cold nights, but harvest was in general progress. Small crops and gardens did well where water was sufficient for irrigation. Frosts and grasshoppers did some damage. Stock in good condition.—*Charles E. Ashcraft, Jr.*

In the following table are given, for the various sections of the Climate and Crop Service of the Weather Bureau, the average temperature and rainfall, the stations reporting the highest and lowest temperatures with dates of occurrence, the stations reporting greatest and least monthly precipitation, and other data, as indicated by the several headings:

Summary of temperature and precipitation by sections, August, 1902.

| Section. | Temperature—in degrees Fahrenheit. | | | | | | Precipitation—in inches and hundredths. | | | | | |
|--------------------------------------|------------------------------------|----------------------------|------------------------|----------|-----------|---------------------------|---|----------------------------|------------------------|---------|-----------------------------------|---------|
| | Section average. | Departure from the normal. | Monthly extremes. | | | | Section average. | Departure from the normal. | Greatest monthly. | | Least monthly. | |
| | | | Station. | Highest. | Date. | Station. | Lowest. | Date. | Station. | Amount. | Station. | Amount. |
| Alabama..... | 82.1 | +2.5 | Newberne..... | 107 | 20 | Hamilton..... | 52 | 25 | Bermuda..... | 11.09 | Letohatchee..... | 0.59 |
| Arizona..... | 81.4 | -0.8 | Casagrande..... | 119 | 5 | Ashfork..... | 35 | 31 | Flagstaff..... | 6.10 | Several stations..... | 0.00 |
| Arkansas..... | 80.6 | +1.0 | Arkadelphia..... | 108 | 4 | Pond..... | 51 | 7 | Corning..... | 7.54 | Perry..... | 0.00 |
| California..... | 71.8 | -1.6 | Saltton, Volcano..... | 121 | 1 | Bodie..... | 17 | 16 | Sisson..... | 4.16 | Many stations..... | 0.00 |
| Colorado..... | 67.1 | 0.0 | Blaine..... | 111 | 4 | Breckenridge..... | 23 | 8 | Cheyenne Wells..... | 6.06 | Pagoda..... | T. |
| Florida..... | 82.1 | +0.7 | Wausau..... | 105 | 21 | Macedenny, Summer..... | 57 | 26 | Molino..... | 9.13 | Quincy..... | 0.92 |
| Georgia..... | 80.3 | +1.3 | Brent..... | 106 | 21 | Clayton..... | 53 | 31 | Harrison..... | 11.11 | Camak..... | 0.90 |
| Idaho..... | 66.5 | -0.8 | Garnet..... | 105 | 2 | Forney..... | 21 | 18 | Pollock..... | 1.32 | Blackfoot, Oakley..... | 0.00 |
| Illinois..... | 71.8 | -2.4 | Equality..... | 102 | 2 | Chenuung..... | 41 | 12 | Urbana..... | 9.79 | Antioch..... | 0.55 |
| Indiana..... | 74.1 | -2.6 | Hallidayboro..... | 14 | 14 | Winamac..... | 40 | 12, 23 | Rockville..... | 5.36 | Vevay..... | 0.70 |
| Iowa..... | 69.1 | -2.0 | Madison..... | 100 | 8 | Sibley..... | 37 | 11 | Columbus Junction..... | 15.47 | Dubuque..... | 1.57 |
| Kansas..... | 78.2 | +1.0 | Mount Vernon..... | 2, 3 | 19 | Achilles..... | 40 | 11 | Moran..... | 14.36 | Lakia..... | 0.84 |
| Kentucky..... | 75.6 | -0.9 | Perry..... | 98 | 19 | Fords Ferry..... | 45 | 12 | Blandville..... | 5.70 | Scott..... | 0.86 |
| Louisiana..... | 84.1 | +2.9 | Garden..... | 112 | 20 | Mansfield..... | 61 | 13 | Schriever..... | 9.69 | Mansfield, Shreveport..... | 0.02 |
| Maryland and Delaware..... | 71.7 | -2.7 | Bowling Green..... | 103 | 3 | Deerpark, Md..... | 33 | 17 | Baltimore, Md..... | 4.31 | Jewell, Md..... | 0.87 |
| Michigan..... | 64.2 | -2.1 | Alexandria..... | 107 | 17 | Newberry..... | 29 | 29 | Port Huron..... | 4.05 | Somerset..... | T. |
| Minnesota..... | 65.2 | -3.0 | Hancock, Md..... | 100 | 31 | Beardsley, Pipestone..... | 52 | 11 | Pipestone..... | 10.60 | Collegeville..... | 1.32 |
| Mississippi..... | 82.7 | +2.5 | Kalamazoo..... | 95 | 3 | Corinth..... | 64 | 25 | Lake Como..... | 7.53 | Thornton..... | 0.50 |
| Missouri..... | 75.0 | -1.3 | Milan..... | 96 | 1 | 6 stations..... | 47 | 7, 11 | Arthur..... | 11.49 | Galena..... | 0.96 |
| Montana..... | 63.1 | -1.1 | Pittsboro..... | 107 | 20 | Adel..... | 25 | 30 | Glendive..... | 2.50 | Manhattan..... | 0.00 |
| Nebraska..... | 71.9 | -1.1 | Marblehill..... | 103 | 3 | Lynch..... | 35 | 11 | Kirkwood..... | 8.74 | Agate..... | 0.22 |
| Nevada..... | 68.9 | -3.1 | Glendive..... | 102 | 24 | Calloway..... | 81 | 18 | Palmetto..... | 2.13 | Several stations..... | 0.00 |
| New England..... | 64.8 | -2.3 | Bridgeport..... | 107 | 1 | Monitor Mill..... | 30 | 17 | Cornish, Me..... | 8.36 | Nantucket, Mass..... | 0.27 |
| New Jersey..... | 70.1 | -2.4 | Rioville..... | 117 | 2 | Fort Fairfield, Me..... | 30 | 17 | Trenton..... | 10.67 | Cancon..... | 1.31 |
| New Mexico..... | 71.3 | +0.3 | Salem..... | 92 | 30 | Layton..... | 40 | 13, 17 | Fort Bayard..... | 7.13 | Albuquerque..... | 0.70 |
| New York..... | 65.0 | -2.1 | Indian Mills..... | 11 | 5 | Winsors..... | 34 | 19 | Adirondack Lodge..... | 6.05 | Volusia..... | 0.79 |
| North Carolina..... | 75.5 | -0.5 | Alamogordo..... | 105 | 5 | Axtion..... | 30 | 13 | Kinston..... | 8.91 | Vennoir..... | 0.90 |
| North Dakota..... | 64.3 | -1.2 | Onconta..... | 94 | 3 | Linville..... | 39 | 28 | Berlin..... | 5.21 | Woodbridge..... | 0.36 |
| Ohio..... | 69.2 | -2.5 | Chapelhill..... | 105 | 4 | Ashley..... | 26 | 11 | Demos..... | 5.86 | Bowling Green..... | 0.18 |
| Oklahoma and Indian Territories..... | 84.2 | +3.1 | 4 stations..... | 96 | 2, 13, 24 | Norwalk..... | 37 | 25 | Tahlequah, Ind. T..... | 6.14 | Jenkins, Okla..... | 0.31 |
| Oregon..... | 66.0 | -0.6 | Camp Denison..... | 97 | 3, 30 | Kenton, Okla..... | 50 | 5 | Jacksonville..... | 1.97 | Several stations..... | 0.00 |
| Pennsylvania..... | 67.8 | -2.0 | Mangum, Okla..... | 114 | 5 | Bend..... | 26 | 18, 28 | Ephrata..... | 6.44 | Erie..... | 0.51 |
| Porto Rico..... | 80.0 | 0.0 | Grants Pass..... | 107 | 6 | Irwin..... | 34 | 17 | Morovis..... | 9.65 | Hacienda Amistad..... | 2.40 |
| South Carolina..... | 78.6 | -0.7 | Huntington..... | 100 | 31 | Cidra..... | 55 | 1 | Batesburg..... | 8.68 | Spartanburg..... | 1.20 |
| South Dakota..... | 68.2 | -3.0 | Cayey..... | 98 | 19 | Heath Springs..... | 55 | 29 | Flandreau..... | 9.84 | Fort Meade..... | 0.07 |
| Tennessee..... | 77.0 | +0.5 | Heath Springs..... | 104 | 22 | Howard..... | 26 | 11 | Arlington..... | 9.36 | Springfield..... | 1.00 |
| Texas..... | 86.1 | +3.1 | Bowdle..... | 101 | 1 | Erasmus..... | 42 | 25 | Kent..... | 3.70 | 49 stations..... | 0.00 |
| Utah..... | 69.4 | -1.0 | Springfield..... | 104 | 14, 21 | Amarillo..... | 52 | 11 | Ranch..... | 2.25 | Promontory, Snow- white..... | 0.80 |
| Virginia..... | 72.9 | -2.6 | Cotulla..... | 110 | 30 | Tropic..... | 23 | 17 | Saxe..... | 5.40 | Stanton..... | 0.00 |
| Washington..... | 64.6 | -0.9 | Green River, Hite..... | 110 | 2 | Loa..... | 31 | 24 | Sedro-Wooley..... | 2.27 | Ellensb'g, Sunnyside..... | 0.00 |
| West Virginia..... | 70.4 | -2.6 | Saxe..... | 100 | 10 | Burkes Garden..... | 38 | 24 | Leonard..... | 5.90 | Cuba..... | 0.97 |
| Wisconsin..... | 65.5 | -2.4 | Newport News..... | 12 | 7 | Wilbur..... | 27 | 27 | Whitchall..... | 7.18 | Westfield..... | 0.38 |
| Wyoming..... | 64.8 | -1.3 | Mottingers Ranch..... | 104 | 7 | Travellers Repose..... | 35 | 17 | Daniel..... | 0.64 | Hyattville, Ther- mopolis..... | 0.00 |
| | | | Echo..... | 98 | 30 | Butternut..... | 30 | 22 | | | | |
| | | | New Martinsville..... | 99 | 1 | South Pass City..... | 25 | 18 | | | | |
| | | | Medford..... | 103 | 3 | Lolabama..... | 19 | 31 | | | | |
| | | | Thermopolis..... | | | Kemmerer..... | | | | | | |

SPECIAL CONTRIBUTIONS.

OCEAN CURRENTS.

By JAMES PAGE, United States Hydrographic Office, dated October 18, 1902.

Every method of investigation thus far employed, whether the drift of floating objects, the comparison of the temperature and the specific gravity of specimens drawn from widely distant points, or the distribution of animal organisms inhabiting different localities, all lend support to the belief that the vast mass of water near the surface of the sea and to a very considerable depth below the surface, even at a distance of thousands of miles from the continental shores and hence far removed from local or tidal current influence, is in motion. The continuity of this motion in certain broad and well-defined regions, such as the Tropics, can not but impress us with the idea that it is in a general way cyclic, that is, that the same water

after a lapse of time retraverses approximately the same path.

The source of the energy required to set and keep this vast mass in motion has been productive of endless discussion. The attractive force of the moon, the vis inertiae or lag of the water itself, the difference in temperature and specific gravity of the equatorial and polar regions, the unequal distribution of atmospheric pressure, each in its turn has been proposed and strenuously advocated as the true and only cause of ocean currents. To the seaman, however, the cause of the ocean currents has always been the winds, since the motion of the waters of the sea takes its origin in the region where the latter attain their maximum constancy, viz, in the region of the trades.

The trade winds cover a belt on the earth's surface extend-

ing roughly over fifty degrees of latitude from 30° N. to 20° S., including within this range a greater water area than could be included in any other position. Throughout this wide zone the wind blows for 90 per cent of the time from some point in the eastern semicircle. In the Southern Hemisphere the trades are somewhat stronger and more constant than in the Northern, owing probably to the freedom from interrupting land areas. Over the eastern half of the ocean they extend far higher in latitude than over the western. This is true of both the northern and the southern hemispheres; the northeast trades in the Atlantic during the northern summer often extend far up on the coast of Spain, the southeast trades during the southern summer often extend beyond the Cape of Good Hope. Similar conditions hold for the Pacific. The southeast trades, too, blow well across the equator in the Northern Hemisphere.

The trade winds, however, are not continuous throughout the entire belt from north to south. Just north of the equator and confined entirely to the Northern Hemisphere are two elongated triangular areas extending east and west through some fifteen degrees of longitude; in the case of the Atlantic Ocean the base of the triangle rests on the coast of Africa; in the case of the Pacific, on the coasts of Central America and Mexico; throughout these areas the trades are absent, their places being taken during a large portion of the year by light, variable winds and calms, during the remainder of the year by winds whose prevailing direction is southwest—the so-called southwest monsoon of the African and American coasts, most apparent during July, August, and September.

THE CHARACTER OF THE TRADE WINDS.

Among those who have not sailed in them the impression is general that the trades blow day after day steadily in one direction and with a constant force. This is distinctly not the case. The trade winds are quite as susceptible to variation, and fortunately so, as the winds of higher latitudes. The one thing about them is that, not being subject to the large variations of barometric pressure which characterize higher latitudes, the wind rarely goes round the compass and, indeed, rarely gets out of the eastern semicircle. As an example of their constancy, let us consider the percentage of winds coming from each compass point for a certain region, for instance, the square bounded by the parallels 20°–25° N. and the meridians 50°–55° W., in the heart therefore of the northeast trades in the North Atlantic. The figures are for the month of June and may be regarded as giving the number of hours in each hundred, or approximately, in four days, that the wind may be expected to blow from the given point:

| Direction and time. | |
|---------------------|----|
| N. | 1 |
| NNE. | 3 |
| NE. | 17 |
| ENE. | 24 |
| E. | 33 |
| ESE. | 8 |
| SE. | 10 |
| SSE. | 4 |

Other squares show similar variations; some greater, some less.

THE IMPULSE COMMUNICATED BY THE WINDS TO THE SURFACE WATER.

Let us now examine the effect of such a system of winds in impelling through surface friction the water with which they come in contact.

If through any cause a thin layer of liquid is set in motion in its own plane with a given velocity, the layer immediately below it, and with which it is in contact, does not remain at rest, but likewise receives an impetus. This second layer exercises a like influence over the third, the third over the fourth,

and so on, the velocity ultimately attained by each successive layer being proportional to its distance from the bottom layer, which is supposed to be at rest. In the case of sea water the rapidity with which this velocity is propagated downward is very slight. It has been calculated, for instance, that a period of 239 years would elapse before a layer at a depth of 50 fathoms would attain a velocity equal to half that at the surface when the surface current is flowing steadily all this time. Such surface currents do not exist, neither do winds capable of producing them exist. The trades, as we have seen, fluctuate from day to day and, indeed, from hour to hour, and the surface currents fluctuate in obedience to them.

It has been stated, however, that the fluctuations of the trades rarely carry them out of the eastern semicircle, and that in point of fact 90 per cent of the winds that blow in the region of the trades do come from that semicircle. There is thus always a westerly component in the motion of the air, coupled with a component which is sometimes northerly, sometimes southerly. For each alteration in the direction of the wind there is a corresponding alteration in the direction of the surface current, the new direction being the resultant of the old direction and the direction which would be imparted to it by the new wind acting alone. These, however, affect only the waters immediately at the surface. Thus, to cite a specific example, observations at the Adlergrund lightship, in the Baltic Sea, have shown that while the water at the surface responds almost immediately to a change in the direction of the wind, the water at the depth of 2½ fathoms does not feel its effects until an interval of 24 hours has elapsed. The steady westerly component is then the only one felt in the region of the trades at some little depth below the surface, and this is sufficient to impart to the entire body of water occupying the equatorial regions of the earth, a westerly motion.

It is of some interest to note the velocity imparted to the surface water by winds of a given force. A comparison of a large number (658) of wind and current observations in the equatorial regions gave as the set imparted by a wind of force 4 on the Beaufort scale, corresponding to 20 miles per hour, a current velocity of 15 miles per day. The figures are taken from the Meteorological Data for Nine 10°-squares of the North Atlantic Ocean, published by the Meteorological Committee of the Royal Society.

The system of surface currents produced by such a system of winds as the trades has been experimentally studied, using for this purpose a miniature ocean, the surface of the water being lightly sprinkled with powder in order to render its motion visible. As soon as the artificial wind was brought into action, a drift was created, and the first tendency was for the water to flow from all sides into the rear of the drift. This gradually extended itself in a sheaf-like form, the marginal threads in the fields untouched or only occasionally touched by the air current leaving the main body, first branching out to the right and left, then, reversing their motion, and finally again working round to the rear of the drift. The central portion of the drift followed a right-line course, in close agreement with the direction of the air currents, until a perpendicular obstacle was interposed. Here the drift divided into two streams, each flowing with the same velocity, but having half the cross section.

This experimental system of currents finds its counterpart in nature. Under the northeast trades in the North Atlantic and the southeast trades in the South Atlantic, we find a broad central drift directed toward the shores of America, the drift from the southeast trades extending well into the Northern Hemisphere, the two uniting some distance off Cape Saint Roque. To the right and to the left of each of these drifts the water fringes off, the direction of the motion is reversed, and the so-called compensating currents manifest themselves. Along the equatorial margin of the two main drifts, under the

equatorial belt of calms, these compensating currents unite to form the counter-equatorial current, or Guinea current, reaching a maximum intensity during June, July, and August, the months of the southwest monsoon. On the polar margin they either return into the drift or are taken up by the general easterly drift of the higher latitudes.

In the equatorial region of the earth we thus have in either ocean three currents. In the North Atlantic the north equatorial current, due to the northeast trades; in the South Atlantic the south equatorial current, due to the southeast trades; between these two the counter-equatorial current, flowing at all times, but reaching a maximum intensity and covering a maximum area at the time of the southwest monsoon. These first two are westbound, carrying the water toward the shores of America; the third is eastbound carrying toward the shores of Africa. They all suffer a slight displacement with the season, in harmony with the movements of the trades, which oscillate slightly in latitude with the movement of the sun in declination. Also in harmony with the fact that the meteorological equator lies slightly to the north of the geographical equator, the south equatorial current extends at all seasons well over into the Northern Hemisphere. Corresponding again with the fact that the southeast trades exhibit greater constancy and strength than the northeast, the south equatorial current shows higher velocity than the north, the average for the latter amounting to but 13 miles in twenty-four hours, for the former to 27 miles in twenty-four hours.

Similar statements hold for the Pacific Ocean. But from this point let us limit ourselves to the Atlantic, the currents for which are not only better known, but also probably better developed, being confined to a less extensive area than the Pacific.

In the Atlantic Ocean, then, the two drifts unite some distance off Cape Saint Roque, the eastern extremity of South America. A portion of the water is diverted to the southward forming the Brazilian current; the main body flows west-northwest along the coast of South America, some entering the Caribbean Sea by way of the passages separating the Windward Islands, the drift through these passages often attaining a velocity of 50 miles a day. The remainder passes to the northward of the islands, forming the Bahama current. In this neighborhood a series of observations by Admiral Irminger of the Danish navy showed that the westerly drift of the water could still be detected at a depth of 900 meters.

A striking instance of the fluctuations of the surface currents with the winds is shown in the case of the straits separating the Greater Antilles, the Windward, and the Mona passage. From January to April, the months when the northeast trades are most northerly in direction and blow with maximum force, a strong southwesterly set is felt upon entering these passages. As the season advances and the trades weaken, at the same time becoming southeasterly, these currents diminish and change their direction to northwest.

Throughout the entire extent of the Caribbean Sea the drift is westerly, save that in those portions where resistance to the flow is offered, such as the southern coast of Cuba, return currents manifest themselves. Throughout the Yucatan passage the drift is northwesterly, but here again the influence of the return current is felt, notably under Cape San Antonio, the western extremity of Cuba, where southeasterly sets are frequent. In the Gulf of Mexico observations have thus far failed to reveal any decided set of the surface water.

THE GULF STREAM.

Between the northern coast of Cuba and the Florida reefs starts the most celebrated of all ocean currents, the Gulf Stream. Discovered by Ponce de Leon in 1513, it has from that time been and still is the subject of scientific investigation.

In the Gulf Stream we have to deal with a current of a na-

ture entirely distinct from those which we have thus far considered. These were all due to the direct action of the wind upon the water, producing a drift. The Gulf Stream is only indirectly due to this cause, being the overflow of the water heaped up by the trade-wind drift in the Caribbean Sea and the Gulf of Mexico. Throughout a considerable portion of its extent, its direction, even at the surface, is independent of the wind or only slightly modified by it. The stream reaches its maximum strength at the point where it emerges from the Bemini Straits between the Bahama bank on the east and the coast of Florida on the west. The breadth of the actual current here between Fowey Rocks and Gun Cay Light is 38 miles, its average depth 239 fathoms, its average velocity 50 miles in twenty-four hours, although it rises at times to 100 miles. Farther north its breadth increases, and its velocity is correspondingly diminished. The western edge of the stream in its northward course along the coast of the United States follows closely the 100-fathom curve, although the axis of the stream, the line of greatest velocity, lies somewhat farther seaward, its position varying, according to Pillsbury, with the declination of the moon, lying (at Jupiter) 8 miles farther off shore at time of low moon than at time of high. From Jupiter to Hatteras the axis runs at a distance varying from 11 to 20 miles outside the 100-fathom curve.

The color of the stream is a perceptibly deeper blue than that of the neighboring sea, this blueness forming one of the standard references of the nautical novelists. The depth of color is due to the higher percentage of salt contained, as compared with the cold green water of higher latitudes, observation having shown that the more salt held in solution by sea water the more intensely blue is its color. Thus even in extra-tropical latitudes we sometimes observe water of a beautiful blue color, as for instance in the Mediterranean and in other nearly land-locked basins, where the influx of fresher water being more or less impeded, the percentage of salt contained is raised by evaporation above the average.

Another important fact in connection with the Gulf Stream is its almost tropical temperature, due to the fact that its high velocity enables it to reach the middle latitudes with very little loss of heat. Upon entering its limits, the temperature of the sea water frequently shows a rise of 10° and even 15°. It was this fact that gave to the stream in the later years of the eighteenth century and the earlier years of the nineteenth an importance in the minds of navigators that it no longer possesses. In those days the chronometer, invented by Harrison in 1765, was still an experiment. Instruments were crude and nautical tables often at fault. The result was that the determination of the longitude was largely a matter of guesswork; a vessel after a voyage from the channel to America was often out of her reckoning by degrees instead of by minutes. The idea, first suggested by Benjamin Franklin, that the master of a vessel, by observing the temperature of the surface water, could tell the moment of his entry into the Gulf Stream, and hence could fix his position to within a few miles, was hailed with delight. The method was published in 1799 by Jonathan Williams in a work lengthily entitled "Thermometrical Navigation, being a series of experiments and observations tending to prove that by ascertaining the relative heat of the sea water from time to time, the passage of a ship through the Gulf Stream, and from deep water into soundings, may be discovered in time to avoid danger." In this work he makes the patriotic comparison of the Gulf Stream to a streak of red, white, and blue painted upon the surface of the sea for the guidance of American navigators.

The discovery of the stream is also alleged to have exercised a curious effect upon the commerce of some of our southern cities. In early days, when the only known sailing route was by way of the trades, it was the custom for vessels making the voyage from Europe late in the year to winter and refit at

Charleston or Savannah before attempting to reach the more northern ports of Boston and New York. The prevalence of northwesterly gales along the coast during the winter season renders the passage a trying one even to the larger ships and with the better navigation of the present time. The southern cities thus became, to a certain degree, half-way houses on the voyage, greatly to the benefit of their trade. With the aid of a thermometer, however, a vessel once making the stream was enabled to remain within it and to be thus borne along by the current until the desired northing was made, after which she headed up for port. Thus the necessity for making Charleston or Savannah was obviated and the advantage which they had hitherto enjoyed as commercial centers was lost.

From Hatteras the course of the stream leaving the coast bears toward the east-northeast. It ceases to exist as a stream current—that is, as a current which runs independently of the winds—shortly after crossing the fortieth parallel; even previous to that, the current observations in the square bounded by 35°–40° N., 65°–70° W. (off the coast from Hatteras to Sandy Hook) show for September, the month of maximum frequency, but 32 per cent of the whole number of observations setting northeast—i. e., only 7 per cent more than 25 per cent, which would be the number if there were no directive influence whatever. In this latitude the Gulf Stream becomes part and parcel of the general easterly drift which characterizes the waters of the ocean north of 35° in a manner quite analogous to the westerly drift of the Tropics and due to the same cause, namely, the prevailing winds, which, however, show none of the persistency of the trades.

The winds of the North Atlantic Ocean—as also of the several other oceans, the South Atlantic, South Pacific, North Pacific, and the Indian—are governed mainly by the presence of an almost permanent area of high barometer covering the main body of the ocean, around which the winds constantly circulate; the circulation in the Northern Hemisphere is in the same direction as the hands of a clock; in the Southern Hemisphere in a contrary direction, or in either hemisphere “with the sun,” as it is expressed by sailors. In the North Atlantic the center of this area lies somewhat to the southwest of the Azores. On the southern slope of this barometric area the winds have an easterly direction, the northeast trades; on the northern slope, a westerly. These westerly winds, however, exhibit none of the constancy of the trades, being frequently interrupted by the wind systems proper to the alternate areas of high and low barometer which move across continent and ocean from west to east, and which form the governing feature of our own weather, the wind backing to the southeast with falling pressure, but hauling to northwest with rising, just as in the case of the trades, only to a much less extent. There is, however, a sufficient easterly component remaining to impart to the waters of the sea below the surface a distinct easterly motion, while on the surface itself there is apparently an utter lack of definite direction other than the fact that the direction of the current ordinarily agrees with the direction of the wind. How true this is may be gathered from a comparison of the observed winds and the observed currents for a given area. Take, for instance, the 5° square included between the parallels 40° and 45° N., 30° and 35° W.—about the middle of the Atlantic Ocean: The total number of wind observations recorded for the square was 8,898; that of reliable current observations, 719. Dividing each of these up into quadrants and setting the currents under that wind quadrant to which they are due, we have the following percentages:

| | NE. | SE. | SW. | NW. |
|---------------|-----|-----|-----|-----|
| Winds..... | 16 | 20 | 36 | 28 |
| Currents..... | 20 | 18 | 31 | 31 |

THE CONSTRUCTION OF CURRENT CHARTS.

For our knowledge of the surface currents of the sea as

tabulated in the current charts used by navigators, or the movements of the waters as they actually take place, we were for a long time wholly dependent upon ships' observations. When at sea the position of a vessel at noon of each day is determined by two independent methods. The first of these is known as the position by observation, and as its name implies, means the position of the vessel as found by actual astronomical observation. The second is known as the position by dead reckoning, and is the position as found by reckoning up the vessel's progress from noon of the previous day, the compass giving the direction, the log the speed. In a majority of cases these two positions fail to agree. The astronomical position is then assumed to be correct, and the difference between them is set down as the current during the intervening twenty-four hours.

Thus let *A* be the position by observation at noon of a given day; *B'* the position by dead reckoning at noon of the following day, i. e., the position derived from a consideration of the course and distance during the intervening twenty-four hours. Suppose, however, that astronomical observations show that the actual position of the vessel at noon of the second day is at *B*. In this case *B'* *B* will be set down in the log as the current experienced during the intervening twenty-four hours. In case no astronomical observations can be obtained, as happens in fog or cloudy weather, the position by dead reckoning has to be adopted as the best obtainable, with the result that if such weather continues for several days in succession, as sometimes happens at certain seasons of the year, the true position of the vessel may differ considerably from the assumed position. To lessen the chance of disaster these current charts have been constructed, giving the results of current observations in the past, and the master of a vessel, by reference to them, is able to profit by the experience of those who have sailed over the same waters in previous years, and to some extent correct his own dead reckoning.

The current charts of the various oceans published by the British Admiralty, the charts which are universally employed by navigators, are the result of many thousands of observations taken since 1830. A glance at these charts will make plain the difficulty which confronts the navigator when approaching a dangerous coast, such as that of Newfoundland or of France, and compelled to rely upon his dead reckoning.

For a knowledge of the motions of the water throughout longer periods of time we are forced to depend upon the drift of floating objects, derelicts, wreckage, floating bottles bearing messages, and the like. All these objects are charted on the drift charts of the United States Hydrographic Office month by month. Two special attempts recently made to study the currents of the sea by this method deserve attention. The first is an effort to obtain a knowledge of the currents in the Arctic Ocean. Stout oaken casks, each one numbered and bearing a message, have been distributed by the Philadelphia Geographical Society among the whalers bound for the Arctic Ocean by way of Bering Sea, who winter in the vicinity of the mouth of the Mackenzie River. These casks are to be placed upon the ice as far eastward as circumstances permit, and the expectation is that they will enter the Atlantic Ocean either by Davis Strait or Barents Sea,¹ be noticed by passing vessels, and picked up. A letter from Dr. Bryant, the president of the society, states that 35 out of the 50 casks have been already sent out, and that in his opinion they may be looked for on the other side of the circumpolar area about a year from the spring of 1902.

The second project is the proposed investigation of the current in the neighborhood of Ushant and Finisterre by means of floating bottles. This has been undertaken by Lloyds, the great firm, of ship underwriters and has probably been sug-

¹That part of the Arctic Ocean between Spitzbergen, Nova Zembla, and Greenland.

gested by the number of vessels lately lost in that vicinity, owing to the fact that they were out in their reckoning. The bottles, which are of gutta percha, are to be sealed and thrown into the sea by passing vessels, each one containing a label showing the date and the position at which it was cast adrift. They are then supposed to drift ashore and to be recovered. The expense involved is considerable. On the bottle it is stated that a reward of five francs will be paid for the return to any of His Majesty's consuls—an instance of liberality of expenditure in the acquisition of knowledge which is almost unprecedented.

SUMMER MEETING OF THE AMERICAN FORESTRY ASSOCIATION.

By Prof. ALFRED J. HENRY, U. S. Weather Bureau.

The American Forestry Association held its summer meeting at Lansing, Mich., August 27-28, 1902, under the joint auspices of the Michigan Forestry Commission and the Michigan Agricultural College. The sessions were held in the State Capitol and the Botanical Laboratory of the Agricultural College, Hon. Charles W. Garfield, Vice President of the Association for Michigan, in the chair.

The papers read and discussed at the meeting were for the most part upon practical problems in forestry and forest management, particularly as applied to the conditions which obtain in Michigan. It is gratifying to note in this connection that the people of that State, and indeed those of other States as well, are fully alive to the great necessity of taking prompt action looking to the preservation of their rapidly disappearing forests.

The advanced position that Michigan has taken in industrial affairs during recent years and the development of new industries has drawn rather heavily upon her water resources. The question of the constancy of stream flow and the possibility of developing additional power is now receiving attention so that a very substantial as well as a sentimental interest attaches to the preservation of the forests on the headwaters of her principal rivers.

During the last thirty-five years vast tracts of Michigan pine lands have been cut over and the merchantable timber removed. In many districts the lumberman has been succeeded by the agriculturist, and prosperous farming communities have been established. In other districts, especially in the region northwest of Saginaw Bay, the attempt at farming has not been as successful as might be wished. Many tracts of land from which the lumber has been removed were abandoned, and in course of time reverted to the State.

From the lands thus acquired the State has set apart about 57,000 acres in Roscommon, Crawford, and Oscoda counties as a forest preserve. At the same time a commission was appointed to have charge, not only of the forest preserve, but also of all matters relating to forests and forest management wherein the State was an interested party. Naturally much of the discussion of the meeting turned upon the measures best adapted to the reclamation of the waste lands, pine barrens as they are locally known, in the forest preserve and elsewhere in the State. These lands are for the most part unfit for agricultural purposes. The soil is sandy, coarse in texture, so coarse in fact that its capillary power is exceedingly low. The rain that falls upon it soon passes far below the roots of the scanty flora that now subsists upon it and is lost so far as plant life is concerned. That such a condition is not of recent origin is clearly shown by the fact that the present flora of the region is composed largely of species which have developed structural forms adapted to much less humid regions. On the other hand it should be remembered that a great part of these abandoned lands was once covered by a growth of magnificent white and Norway pine. The important question is therefore "Can not these trees be grown again?"

The consensus of opinion as expressed at the meeting was in the affirmative, but on certain of the poorer lands it would be necessary to first plant trees of a relatively low order in the economy of nature, as for example, the jack pine, a tree that will grow on lands that have been fire-swept and abandoned by other forest trees, or left to waste by the farmer.

The forest, as was pointed out by Dr. Gifford, performs simultaneously two important functions, soil fixation and soil betterment. The improvement of the soil would be a comparatively slow process, yet with the gradual formation of humus and with the added protection of the trees the moisture conditions would also improve, especially as regards the conservation of the snowfall, much of which is now wasted. Thus the way would be paved for the return of the better species of trees.

Mr. Thomas H. Sherrard of the Bureau of Forestry, United States Department of Agriculture, gave a general description of the physical characteristics of the lands in the forest preserve. He classed the existing forest covering as (1) Swamp; (2) Jack pine plain; (3) Oak flat; (4) Oak ridge, and (5) hardwood lands, and showed the distribution of these types in a representative township. Mr. Sherrard also gave an estimate of the possible production of a second crop of timber on these lands based upon measurements of existing second growth.

The climatologist will be interested chiefly in the deliberations of the several sessions respecting the destruction of the forests, the blighting effect of forest fires, and the diminution of stream flow due to these causes. Fortunately for the State, the scars made upon her surface are not so deep or lasting as they might have been under different conditions as to climate and topography. The rainfall is generally abundant for all needs, though not heavy enough to cut and seam the surfaces from which the timber has been removed. Then, too, owing to the humid climate, the original forest has in many cases become covered with a second growth of native trees or underbrush, thus preserving the character of the original covering. So far as can be judged from the scanty data available, deforestation has not changed the climate to an appreciable degree.

THE PERMANENCY OF PLANETARY ATMOSPHERES, ACCORDING TO THE KINETIC THEORY OF GASES.

By S. R. COOK, Case School of Applied Science, Cleveland, Ohio, dated September 3, 1902.

1. HISTORICAL.

Since the development of the kinetic theory by Clausius, Meyer, and Maxwell, and especially since it has been shown by Maxwell and Boltzmann that the molecules of any gas may have velocities ranging from zero to infinity, it has been a problem of intense interest to many scientists to determine the probability that the molecules of highest velocity may escape from the outer limits of an atmosphere, and hence deduce the condition of atmospheric permanence.

The vast extent of the gaseous envelope of the sun, the absence of an atmosphere around the moon, the extent and permanency of the atmosphere of the earth and the probable existence of atmospheres on the planets are problems that arouse and hold the interest alike of astronomers and physicists.

According to the nebular hypothesis, these bodies at one time all belonged to the same nebulous mass. It may then very naturally be assumed that under similar [temperature] conditions they would each contain the same forms of matter in their atmospheres. Various hypotheses, both chemical and physical, have been presented to explain the absence of all free gases from the surface of the moon. The presence of certain markings on Mars, that appeared to be accounted for by atmospheric conditions, has caused much interesting speculation and scientific discussion as to the probable constitution of this planet's atmosphere. The existence at times of what